



The Coming Copper Peak

Production of the vital metal will top out and decline within decades, according to a new model that may hold lessons for other resources

IF ELECTRONS ARE THE LIFEBLOOD OF A modern economy, copper makes up its blood vessels. In cables, wires, and contacts, copper is at the core of the electrical distribution system, from power stations to the delicate electronics that can display this page of *Science*. A small car has 20 kilograms of copper in everything from its starter motor to the radiator; hybrid cars have twice that. But even in the face of exponentially rising consumption—reaching 17 million metric tons in 2012—miners have for 10,000 years met the world's demand for copper.

But perhaps not for much longer. A group of resource specialists has taken the first shot at projecting how much more copper miners will wring from the planet. In their model runs, described this month in the journal *Resources, Conservation and Recycling*, production peaks by about midcentury

even if copper is more abundant than most geologists believe. That would drive prices sky-high, trigger increased recycling, and force inferior substitutes for copper on the marketplace.

Predicting when production of any natural resource will peak is fraught with uncertainty. Witness the running debate over when world oil production will peak (*Science*, 3 February 2012, p. 522). And the early reception of the copper forecast is mixed. The work gives “a pretty good idea that likely we’ll get a peak somewhere around midcentury,” says industrial ecologist Thomas Graedel of Yale University. Technological optimists disagree. “Not that it couldn’t happen, but I don’t think it’s likely to happen,” says resource economist John Tilton, research professor emeritus at the Colorado School of Mines in Golden. New and better technology for extracting cop-

per from the earth has always come to the rescue before, he notes, so he expects a much-delayed peak that businesses and consumers will comfortably accommodate by recycling more copper and using copper substitutes.

The copper debate could foreshadow others. The team is applying its depletion model to other mineral resources, from oil to lithium, that also face exponentially escalating demands on a depleting resource.

So far, so good

The techno-optimists were right about copper in the past. From nearly nothing in the mid-18th century, copper production soared along an exponential curve notched only by world wars and economic crises. That’s all the more impressive considering the accompanying decline in the richness, or grade, of the ore being mined. Anyone extracting a

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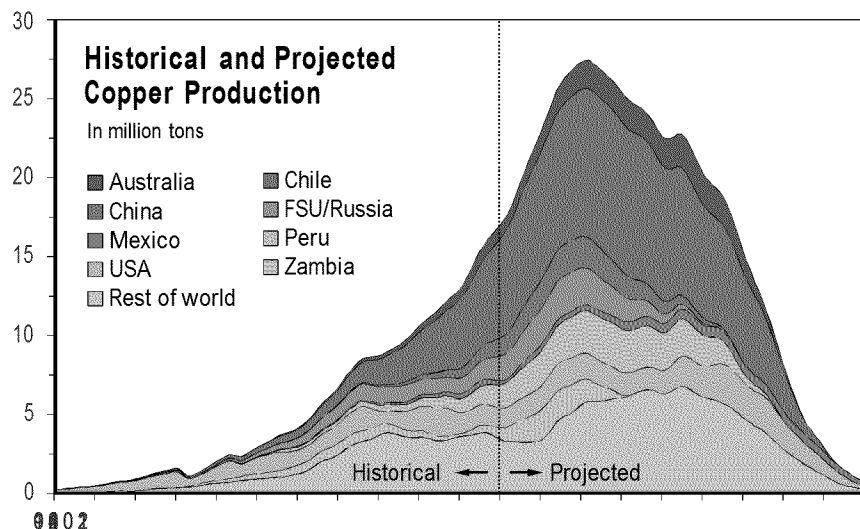
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Postpeak options. The price spike at peak copper will drive even
more recycling of scrap (above). U.S. pennies used to be pure
copper (far left), but now they are copper-plated zinc; substitu-
tions in major uses of copper will be far less satisfactory.

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